LOW-FREQUENCY SEA SURFACE SCATTERING LEVELS AS A FUNCTION OF STABILITY

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LONG-TERM GOAL

There are some remaining unexplained issues in our understanding of low-frequency scattering of acoustic energy below the sea surface. It is hoped that these experiments and subsequent studies will contribute to the resolution of these issues.

SCIENTIFIC OBJECTIVES

The goal of the research is to acquire measurements of low-frequency monostatic surface scattering coefficients under a range of surface thermal conditions, in an attempt to confirm a correlation of temperature stability with scattering levels. The hypothesis of Goodman and Gilbert is that, in addition to wind speed, water column stability plays an important role in determining bubble cloud structure and hence backscatter strength.

APPROACH

The USNS HAYES will be used as a reverberation measurement platform. This ship is designed for acoustic trials, with very low self-noise and ample calibrated data acquisition systems. These systems will be used on a not-to-interfere basis to acquire recordings of reverberation signals. The sources will be low-cost light bulbs, weighted and dropped over the side. Data processing can also be done using the existing NSWC-CD facilities. This approach has been shown to be adequate based on the preliminary experiments.

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WORK COMPLETED

A total of 34 drops of light bulbs were recorded in two experiments conducted in Nov. and Dec., 1996. Environmental data as well as acoustic recordings were made. The dominant frequency of the light bulb implosions is about 400 Hz, and the implosion depth varied from 60 - 180 m. The data were processed to display reverberation levels, and plots of these have been generated. Since the geometry is known, it is possible to infer the levels of surface scattering from the reverberation vs. time plots.

RESULTS

1. Feasibility of using HAYES as a measurement platform on a not-to-interfere basis has been established, and this usage can include the ship's crew and equipment for data collection. Little special training is needed to perform the experiments.
2. Light bulbs (particularly 11.4-cm dia. 'globe' type bulbs) have been identified as low-cost reverberation sound sources, and the levels and implosion depths of various bulbs have been determined. There are some limitations in their use, however; namely the rather narrow bandwidth of the sources and their limited acoustic energy output.
3. Surface scattering levels in the 400 Hz region were found to be consistent with those predicted by the Ogden-Erskine model for the 20-knot wind speed that prevailed during our measurements, although the statistical quality of the results is limited due to the limited number of measurements and the relatively narrow bandwidth of the source spectrum.

IMPACT/IMPLICATIONS

The success of the initial 'demonstration' experiments indicates that it would be possible to use HAYES as a platform on a long-term basis to collect acoustic scattering data as a function of weather conditions. Since HAYES is on-site in the Bahamas about a third of the time, this offers many opportunities to collect data across a wide range of weather conditions (wind speed and stability in particular). It is anticipated that the HAYES crew can be prepared to conduct these experiments as requested, whenever there is a short period of time available between mission tasks.

TRANSITIONS

The results of these experiments may lead to improvements in low-frequency surface scattering models and theories, which can then be incorporated in Navy standard models such as REVGEN and the Generic Sonar Model, which is used in the Navy community and the Fleet for sonar predictions.

RELATED PROJECTS

On the oceanographic side, Thorpe proposed an investigation of the effect of air bubbles in seawater as a source of backscattering excess; his report is:

S.A. Thorpe, "On the clouds of bubbles formed by breaking windwaves in deep water, and their role in air-sea gas transfer", Proceedings of the Royal Society of London (1982).

Goodman reported on the acoustical implications of this at a conference in Italy, K. K. Bekkar, K.E. Gilbert, and R. R. Goodman, "The effect of water column stability on acoustic backscatter from the ocean bubble layer", Proc. of Conference on High Frequency Acoustics in Shallow Water, Lereci, Italy, 30 June-4 July 1997.

Pete Ogden and Fred Erskine of Naval Research Laboratory have conducted experiments to refine the surface scattering empirical models. These empirical models were compared with the light bulb measurements. Their published reports include the following:

P. O. Ogden and F. T. Erskine, "An Empirical Prediction Algorithm for Low-Frequency Acoustic Surface Scattering Strengths", Naval Research Laboratory report NRL/FR/5060-92-9377 (Apr. 28, 1992).

P. O. Ogden and F. T. Erskine, "Surface Scattering measurements using broadband explosive charges in the Critical Sea Test experiments", J. Acoust. Soc. Am. 95, pp. 746-761 (1993).
The surface scattering investigations, particularly in littoral waters, are now being led by Dr. Roger Gauss at NRL. His recent work is reported in "Long range measurements of the strength and spectral character of low-frequency surface reverberation", R.C. Gauss, R. J. Soukup, D.M. Fromm and J. J. Fialkowski, J. Acoust. Soc. Am. 94(3), 1765 (A).

Harry DiFerrari and others at the Univ. of Miami have conducted long-term low-frequency scattering experiments off Florida (ASREX, acoustic surface reverberation experiment). Their recent work was reported at the ASA meeting in Washington in May 1995. This is a littoral water environment in which air-sea interactions may differ from our deep-water conditions, but more information about both environments is relevant to the questions being investigated.